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Wind erosion in a small catchment of grazing area in Northern Burkina Faso: influence of surface features

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Introduction

Wind erosion studies in the Sahel mainly relate to cultivated field (e.g. Bielders et al. 2001), but there is a lack of information about natural areas where grazing is major land use. In a context of increasing population these areas are reported to degrade due to drought enhanced by overgrazing. Such a degradation seems obvious from observations: Typically the non cultivated areas show a patchwork of bare crusted soil, in some cases covered with gravel originating from overlaying laterite, and sandy soils where perennial and annual vegetation grow. These bare or graveled areas are reported as degraded. Nevertheless Casenave and Valentin (1989) suggested that a dynamic may exist leading to extension or regression of bare crusted/graveled areas according to drought and rainier years respectively. The purpose of this paper is to assess the aeolian dynamics of such typical Sahelian surface features by direct measurements of wind erosion flux.

Methods

Study area. The study area is located in the north of Burkina Faso (UTM30, WGS84, 809847 m East, 155093 m North), near Dori, 250 km North East of Ouagadougou (Fig. 1). The climate is of the Sahelian type, with a long dry season and a short rainy season from June to September (Mean rainfall 512 mm). Wind erosion measurements are performed on a small catchment because this study is a part of a larger program aiming at studying for the same surface wind and water erosions. The surface features of the catchment was mapped from aerial photographs and direct observations in the field according to the classification of Casenave and Valentin (1989, 1992). These observations allowed to select three sub-areas homogeneous in term of surface feature combination.

Wind erosion measurements. Measurements were performed during the 2001 rainy season between June 1 and October15. Wind blown sediment fluxes were obtained by using 50 masts equipped with 3 BSNE sand catchers (Fryrear, 1986) located at heights 0.05, 0.15 and 0.3 m. The masts were placed 1) approximately every 20-m on the boundaries of the sub-areas and 2) along a transect in the western side of the catchment where the surface feature variability is higher (Fig. 1). Wind blown sediments caught in BSNE were collected after each erosion event. The horizontal fluxes were calculated at each mast by integrating the sediment flux density profile between 0 and 0.4 m height.

The mass budgets within the selected areas were calculated by subtracting outgoing from incoming wind blown sediments. Wind speed and direction were measured at 2 m height using an automatic weather station. An acoustic saltation sensor (Saltiphone) recorded the period during which the fluxes were significant. Knowing that, it was possible to estimate the mean direction of wind during each storm event, and to determine for each event the upwind and downwind limits of sub-areas. The incoming and outgoing mass fluxes along these boundaries were then calculated by linear interpolation of sediment mass fluxes measured at each mast. The transect was oriented along the East / West direction (Fig. 1) which was assumed to correspond to the more intense wind erosion events. On the transect, the BSNE masts are setup at each major surface feature change. When erosive wind direction corresponds to the transect direction (95° +- 15°), it is possible to compute a budget by subtracting downwind from upwind fluxes and dividing the result by the distance between the two considered measurement location.

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Results and Discussion

Surface features. According to Casenave and Valentin (1992) classification four types of surface features can be pointed out on the catchment (Fig. 1): i) areas of sandy soil developed on aeolian sand deposits (less than 0.7 m thick) where annual vegetation, shrubs and trees grow and where the crust type is mainly drying (DRY), ii) large areas of bare clayey soil with typical erosion crust (ERO), iii) stretches of unvegetated sandy soil with erosion crust which always develop between the two former types (ERO/S), and iv) small sand fan without vegetation deposited by water (RUN) (Ribolzi *et al.*, 2000). The first two surface features clearly dominate and are not randomly distributed on the catchment (Fig. 1): in the upstream part (#1), only DRY are represented, on the center of the catchment (#2) ERO is patched within dominant DRY (about 30 and 80 % respectively) whereas in the downstream part (#3) the reverse is observed i.e. small patches of DRY crust within ERO (about 20 and 80 % respectively).

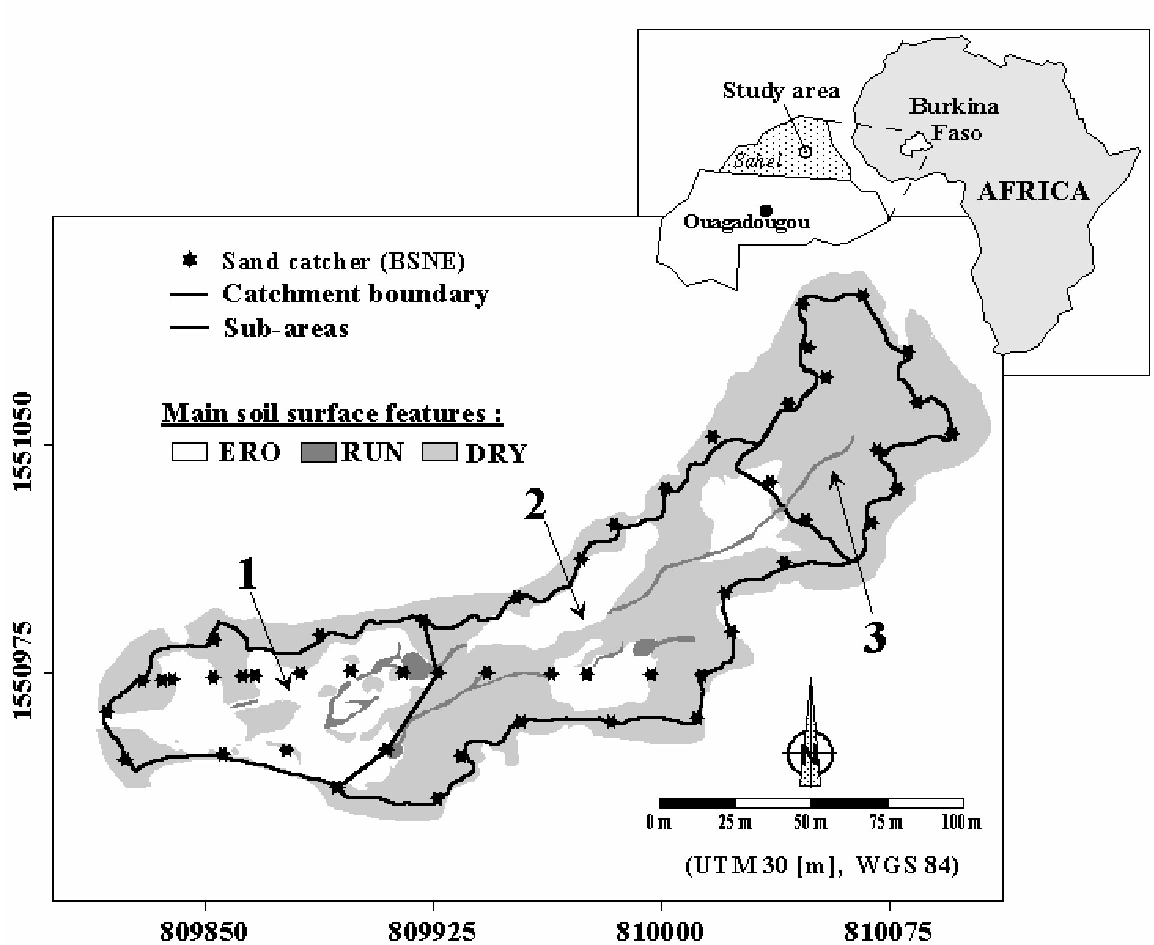

Figure 1. Situation of the study area, map of soil surface features, location of BSNE clusters, and limits of the 3 sub-areas for which wind budget was calculated.

Wind blown sediment budget. Budgets were computed from a set of 21 flux measurements out of 34 for which the standard deviation of wind direction is smaller than 20°. These 21 wind erosion events represented more than 80% of the total flux recorded during the season and are assumed to be representative of the overall wind erosion (Rajot et al. 2002). Figure 2 shows that the budgets vary considerably according to the time and space.

Eighty five percent of the total sediment mass flux measured over the study period occur before the 15 July. Such a result is well known in the Sahel and can be related to higher wind intensity and to lower soil coverage by litter and vegetation at the onset of the rainy season (Rajot 2001).

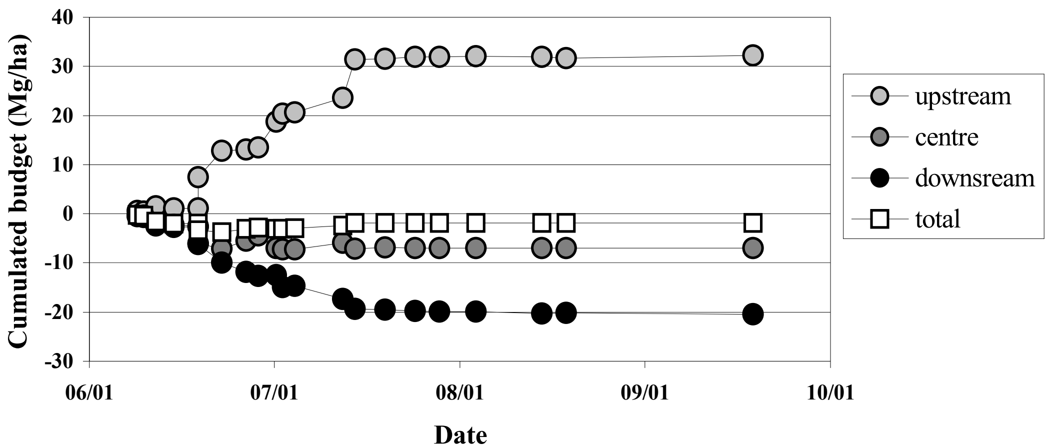

Figure 2. Wind blown sediment mass budget (Mg ha^{-1}) cumulated over the study period for the total area and the 3 sub-areas selected because of their surface feature distribution.

Budget is almost systematically positive for the upstream sub-area (#1) whereas it is systematically negative for the downstream one (#3), amounting to about + 30 Mg ha^{-1} and -20 Mg ha^{-1} over the measurement period, respectively. Both erosion and deposition occurred in the center sub-area (#2), but budget remained negative over the measurement period (-7 Mg ha^{-1}). These different behaviors of the sub-areas led to an almost balanced budget (- 2 Mg ha^{-1}) at the catchment scale.

High wind blown sediment deposition was also reported by Bielders et al.(2001) in fallow land in Niger which presented the same surface feature as sub-area 1 (dry crust with annual and perennial vegetation). The deposition was ascribed to the high surface roughness of these areas. In Niger, sources of wind blown sediments were the pearl millet fields (Bielders et al., 2001). In this study, net wind erosion occurred on complex natural areas where all the different surface features encountered in the catchment are represented (Fig. 1).

The transect measurements performed across sub-areas 2 and 3 (Fig 1.) allow a better description of the processes occurring in relation with these surface features. Only 5 events met the required wind direction to be computed from the transect set up, but 2 of them are the more intense of the season. General trends appeared and can be summarized from the budget computed from the sum of these 5 events (Fig.3). First of all, the transect revealed the high spatial variability of wind erosion at the meter scale. There is not a systematic behavior of the 2 main surface features in regards to budget :

erosion may occur on DRY surface and deposition may occur on ERO surface. Nevertheless, the larger deposition occurred on DRY surface whereas the more intense erosion occurred on ERO/S surfaces or area where such a surface is present (between 70 and 85 m), as well as on the RUN surface.

ERO/S surfaces are closely associated to DRY ones and develop on the same sandy soil. If one considers these 2 surfaces together (between 0 and 9 m and between 25 to 37 m) sediment budget is negative i.e. the small patches of sandy soil are currently submitted to net erosion as suggested by Casenave and Valentin (1989) during drought conditions.

The fact that net deposition may occur on ERO surfaces whereas sand deposits are not observed on it suggests that these sediments are mobilized by water erosion which often follows wind erosion in the Sahel (Rajot et al. 2002). Similarly the high susceptibility of RUN surfaces to wind erosion shows that water erosion produces sediment which are easily mobilized by wind erosion.

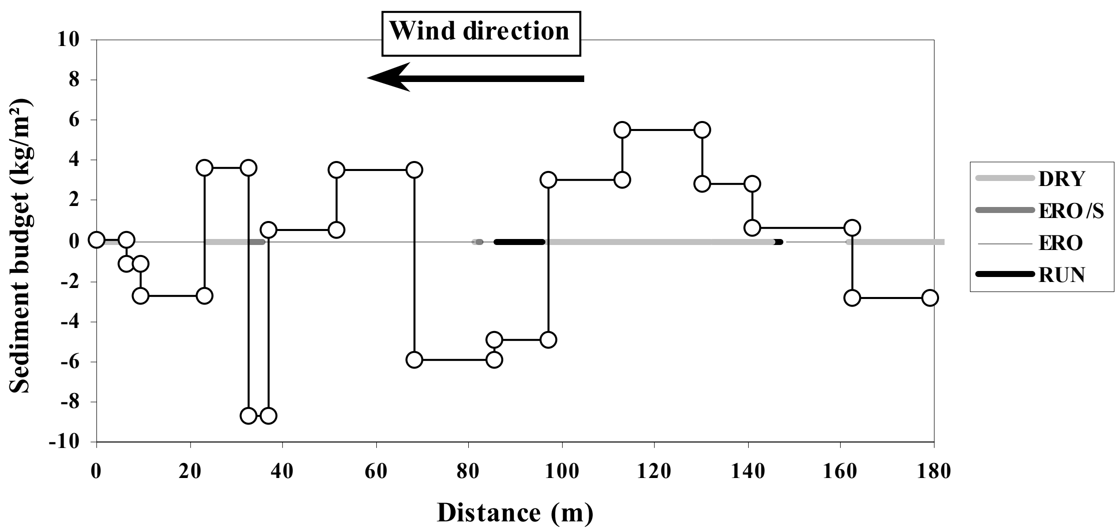

Figure 3. Cumulated wind blown sediment budget for the 5 events with easterly winds (parallel to the transect orientation) versus distance from the west border of catchment. The various types of surface feature (see text for description) are indicated by different shades of gray on horizontal axis.

Conclusions

Wind erosion of grazing areas in the Sahel is an highly variable phenomenon at least from the scale of the meter to that of the hundred of meters. Not only the type of surface feature plays a role in this variability, but also the size of these surfaces. In the study area, the small patches of DRY surfaces associated with ERO/S surfaces are currently submitted to intense wind erosion. Net erosion also occurs in DRY areas with patches of ERO surfaces, whereas only the largest DRY surfaces without ERO crust show a net deposition. These results suggest that the current situation of the grazing area rather corresponds to a general degradation of the environment which can be related to the current drought in the Sahel. Nevertheless, it appears that both wind and water erosions interact and must be taken into account to assess accurately the erosion in this zone.

References

Bielders, C.L., Vrieling, A., Rajot, J.L. and Skidmore, E., 2001. On-farm evaluation of Field-scale Soil Losses by Wind Erosion under Traditional Management in the Sahel. *Proceedings of International Soil Erosion Symposium* – ASAE – Honolulu 1-5 janvier 2001.

Casenave, A., and Valentin, C., 1989. Les états de surface de la zone sahélienne. Influence sur l'infiltration. Paris. *ORSTOM, Coll. Didactiques*. pp. 230.

Casenave, A., and Valentin, C., 1992. A runoff capability classification system based on surface features criteria in semi-arid areas of West Africa. *Journal of hydrology*. 130, 231-249.

Fryrear D.W., 1986. A field dust sampler. *Journal of Soil and Water Conservation* 41 : 117-120.

Rajot, J.L., 2001. Wind blown sediment mass budget of Sahelian village land units in Niger. *Bull. Soc. Géol. France*, 172 (5): 523-531.

Rajot, J.L., Ribolzi, O., and Thiebaux, J.P., 2002. Simultaneous quantification of wind and water erosions within small grazing Sahelian catchments (Burkina Faso – West Africa). *Proceeding of 12th ISCO Conference*, Beijing 26-31 May 2002

Ribolzi O., Auque L., Bariac T., Casenave A., Delhoume J. P., Gathelier R., Pot V., 2000. Ecoulements hypodermiques et transferts de solutés dans les placages éoliens du Sahel : Etude par traçage isotopique et chimique sous pluies simulées. *C. R. Acad. Sci. Paris*, 330: 53-60.